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(56) Documents cited
US 4805416 A US 4768347 A US 4441330 A

(58) Field of search
UK CL (Edition K) F4H
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(54) Refrigerant recovery systems

(57) A one-pass refrigerant recovery and purification system removes refrigerant from a refrigeration unit, filters and purifies it and condenses and stores the refrigerant in its liquid state for reuse. A collection tank (50) is provided which separates the non-condensible gases, thereby eliminating pressure buildup in the storage tank. The non-condensible gases are vented back to the system via an oil separator (24) to selectively provide positive pressure for vacuum relief. The system also includes an oil separator (42) for refrigerant which has passed through a compressor (40) with a feedback line (44) to return the oil to the compressor. The system also includes filters (14, 32 and 34), a cooling coil (46); a condenser (48); and a storage tank (54) for immediate re-use of the refrigerant.

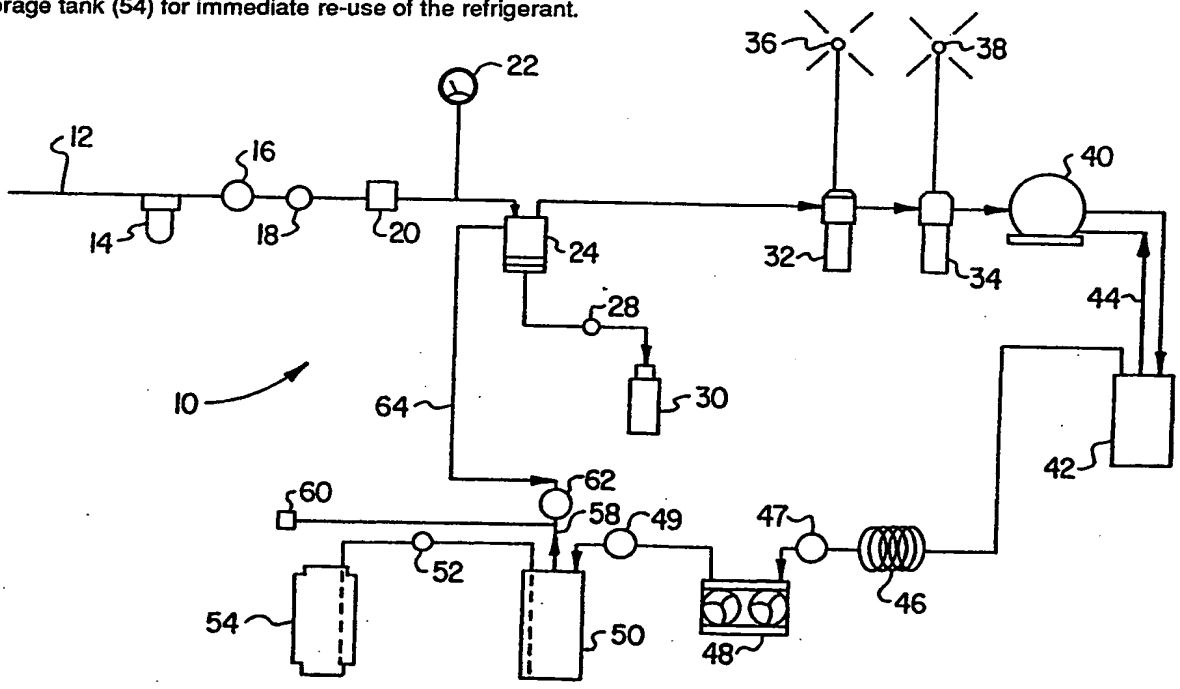

FIG. 1

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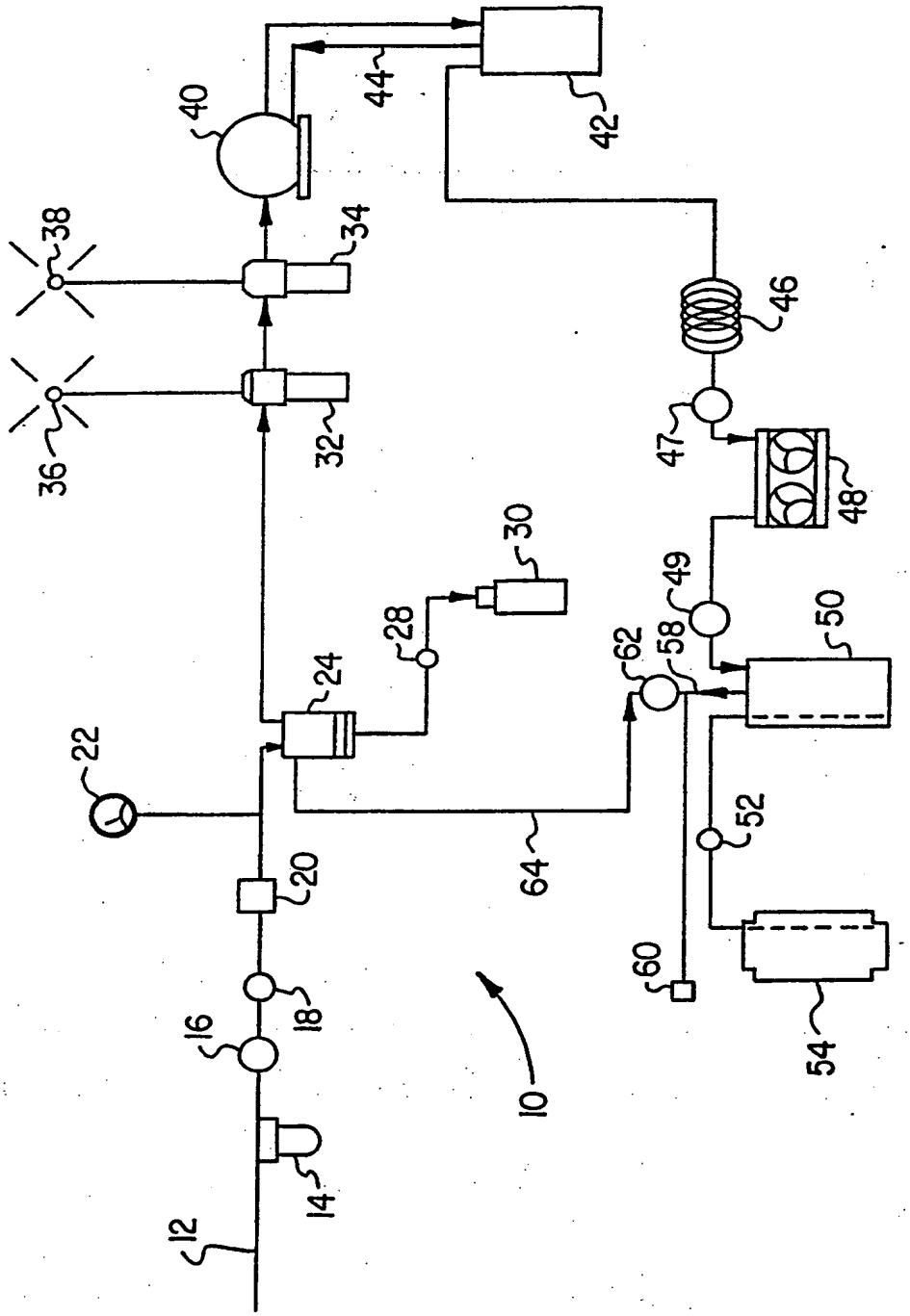
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FIG. 1

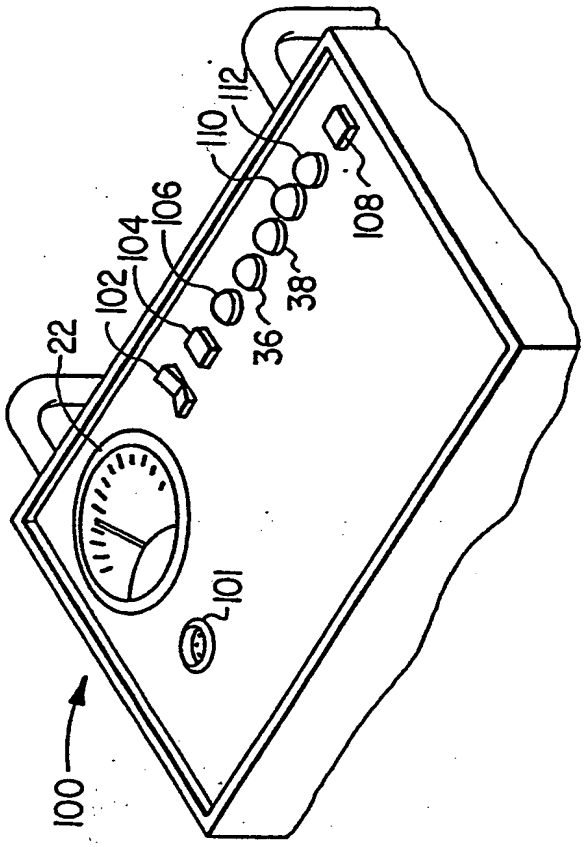
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FIG. 3

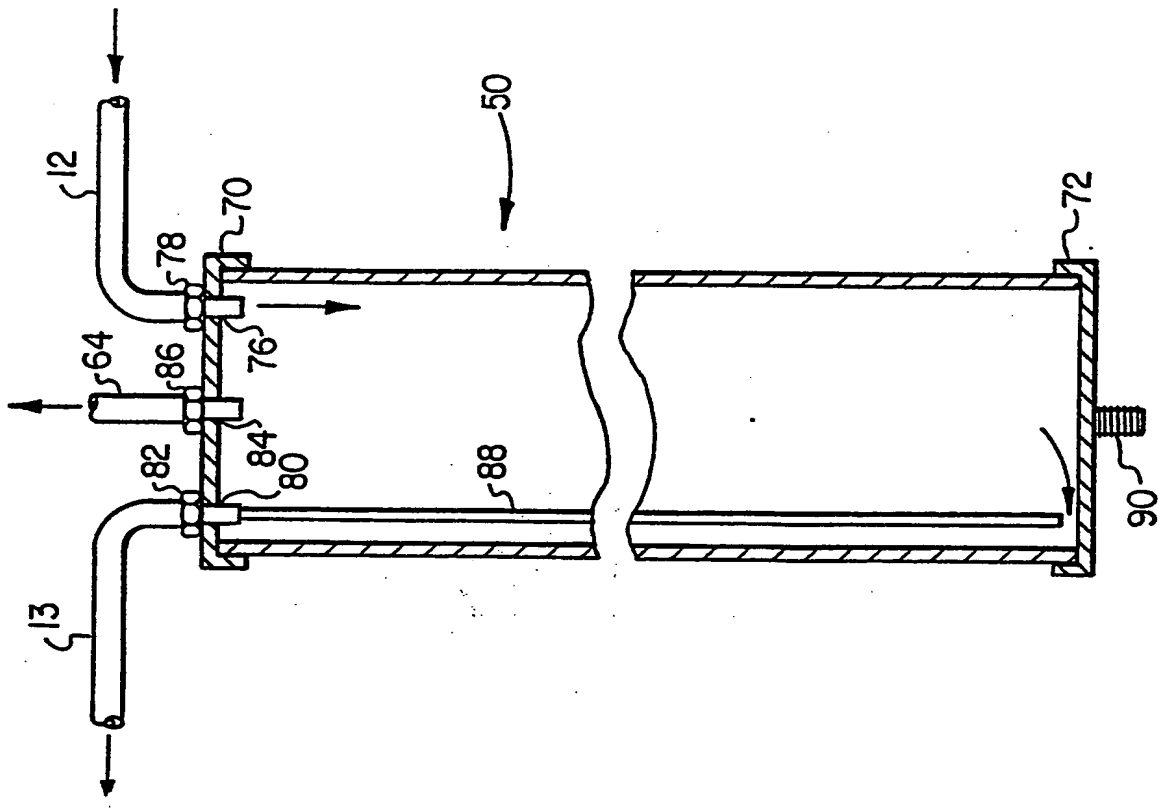
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FIG. 2

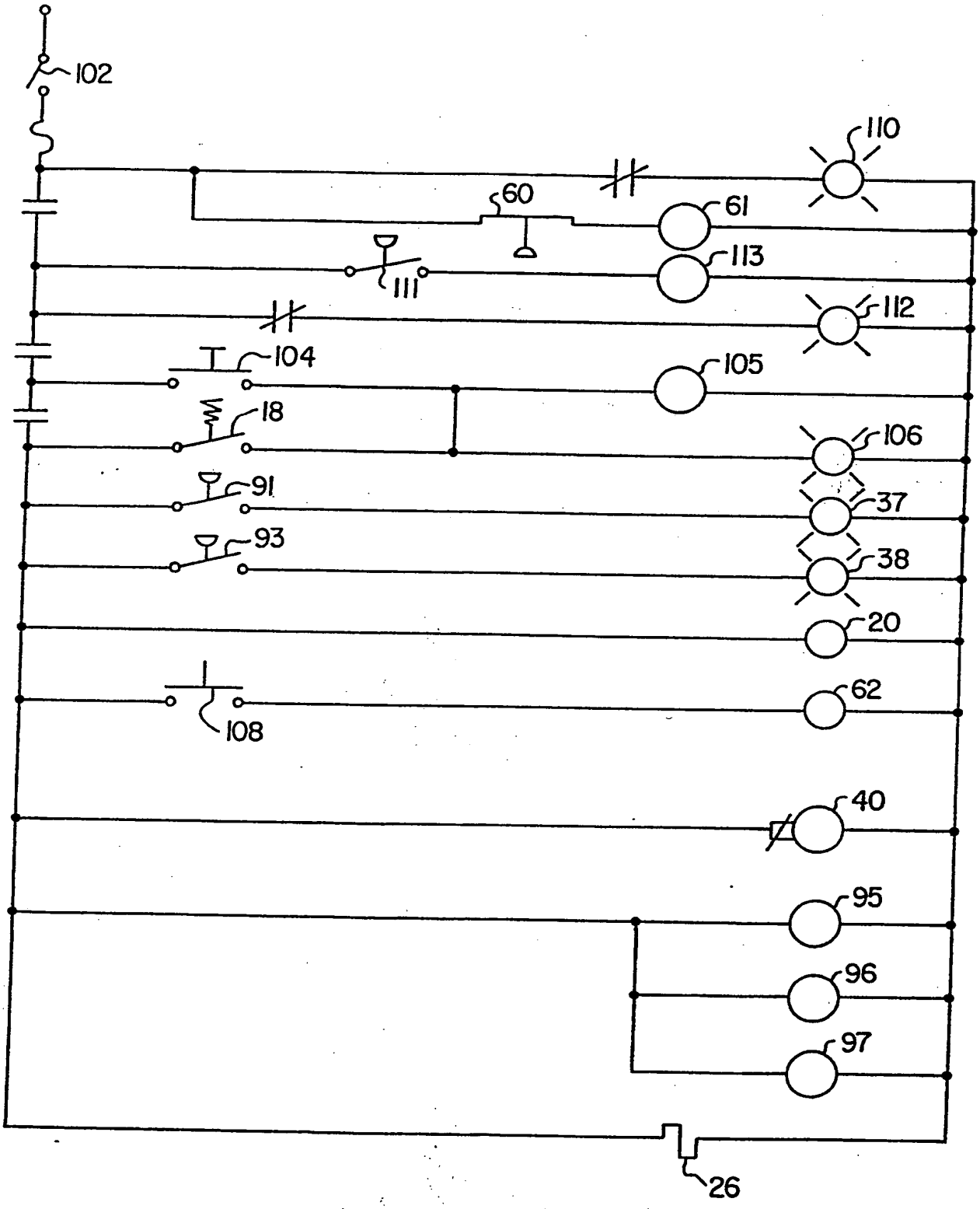
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FIG. 4

REFRIGERANT RECOVERY AND PURIFICATION SYSTEM

The present system is directed to apparatus and methods for recovering and purifying refrigerant from refrigeration systems such as automobile air conditioning systems. More particularly, the present invention is concerned with a one-pass system for removing refrigerant from a refrigeration system, purifying the refrigerant and storing it in its liquified state for re-use.

BACKGROUND OF THE INVENTION

In refrigeration systems, the refrigerant, such as freon, frequently becomes contaminated with moisture, particles and acid and must be replaced. Until recently, it has been common for the old refrigerant to simply be vented into the atmosphere prior to the refrigeration system being recharged. It is now known that such vented refrigerant is harmful to the environment, particularly causing serious contamination to the upper atmosphere and destruction of the ozone layer. Recent legislation has restricted and prohibited such venting activities and requires the used refrigerant to be removed in a closed system and stored for later purification or disposal.

Several systems have been developed for removing and purifying the refrigerant for later usage. U.S. Patent No. 4,805,416 discloses a system for recovery, purification and recharging of refrigerant in a refrigeration system in which a compressor is connected through solenoid valves to a combined heat-exchange/oil separator unit which condenses the refrigerant and separates the oil therefrom. After the refrigeration system has been fully evacuated, the refrigerant recovery system cycles the refrigerant by the continuous operation

of vaporizing, drying and condensing until substantially all of the moisture has been removed.

A similar system is shown in U.S. Patent No. 4,441,330 wherein refrigerant is evacuated from a refrigeration system through a particulate filter, evaporator, compressor and condenser to a storage container. Again, after evacuation, a multiple-cycle purification/drying process is carried out. Thereafter, oil is added back into the refrigerant which is used to recharge the refrigeration system.

In the aforementioned patents and other prior art, the refrigerant recovery unit is essentially taken out of further service when the storage tank has been filled until a purification cycle is completed. This purification process may require from two to eight hours, depending upon the nature of the filtering system. Thus, when a storage tank is full, the recovery unit cannot provide further recovery services until the refrigerant in the tank is purified. Alternately, if the filled tank is replaced by a new storage tank, the refrigerant in the filled tank must be purified later using another unit.

Another difficulty with prior art systems is that certain non-condensible gases have often contaminated the refrigerant and must be removed. For example, air commonly leaks into a refrigeration system and is drawn off when the refrigerant is evacuated. Since most of the air cannot be condensed in the recovery unit, there is a build-up of non-condensible gases in the storage tank with the liquified refrigerant which must be periodically purged to avoid intolerable high pressure.

Yet another problem in prior art recovery systems is the difficulty of venting the systems after the refrigerant has been evacuated. During evacuation, the compressor pumps the refrigerant from the refrigeration system leaving a near vacuum in the recovery unit line after evacuation. It is necessary to vent the line in some manner in order to change filters.

However, in doing so, refrigerant may be vented to the atmosphere resulting in the detrimental effects discussed earlier.

SUMMARY OF THE INVENTION

The present invention overcomes the problems of the prior art by providing a one-pass system which purifies the refrigerant in a single pass through the recovery system, following which the liquified refrigerant is stored for immediate re-use. The invention of the present system also removes the non-condensible gases before they reach the storage tank thereby eliminating the high pressure build-up in the storage tank. The present system also provides positive pressure means within the system to eliminate the vacuum after evacuation is finished so that the line may be serviced.

The present invention provides a system for recovering and purifying refrigerant from a refrigeration system including compression means for removing the refrigerant from the refrigeration system, oil separation means for removing the oil from the refrigerant, filter means for substantially removing the moisture from the refrigerant, condenser means for liquifying the refrigerant, collection means for removing non-condensible gases from the refrigerant and storage means for storing the liquified refrigerant. The collection means includes a device for removing and venting substantially all of the non-condensible gases from the refrigerant. The non-condensible gases are directed back into the system after evacuation so as to remove the vacuum in the system by a positive pressure feed. The filter means are designed to substantially remove all of the moisture from the system in a single pass through the system to eliminate the purification cycle required by the prior art.

The system of the present invention preferably also includes a particulate filter means for removing contaminants from the refrigerant, a first oil separator removing oil from the

refrigerant before the compressor, a second oil separator which removes oil from the refrigerant after having passed through the compressor and a return line for feeding the separated oil back to the compressor. This system further includes a quick-change canister for each of the filters to facilitate replacement of the filters, and filter indicators to show pressure build-up in the canisters requiring filter changes.

The invention of the present system also includes a method of recovering and purifying the refrigerant in a refrigeration system, including pumping the refrigerant from a refrigeration system substantially in vapor form, removing particulate matter from the vaporized refrigerant, separating oil from the vaporized refrigerant, substantially removing the moisture from the vaporized refrigerant, substantially condensing the vaporized refrigerant, removing the non-condensible gas from the liquified refrigerant before storage and then storing the liquified refrigerant.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention and its additional features and advantages are best understood from the following description, claims and drawings in which:

FIG. 1 is a schematic diagram of a refrigerant recovery and purification system in accordance with a preferred embodiment of the invention;

FIG. 2 is an elevational cross-section view of the collection tank of the embodiment of the invention shown in FIG. 1;

FIG. 3 is a plan view of the control panel of the embodiment of the invention shown in FIG. 1; and

FIG. 4 is a circuit diagram for the electrical circuitry of the embodiment of the invention in FIG. 1.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

FIG. 1 illustrates a preferred embodiment of the refrigerant recovery and purification system 10 of the present invention. The system 10 includes an input line 12 connected to the refrigeration system containing refrigerant to be processed. Line 12 feeds to a particulate filter 14 which removes most of the particles from the refrigerant. Preferably particulate filter 14 has a 15 micron (15 micrometre) core and is mounted in a threaded bowl/lid canister or other container enabling easy and quick change-out of the core.

A one-way check valve 16 stops refrigerant from escaping when the system is shut off. A conventional vacuum switch 18 is connected to check valve 16 and shuts off the system when the pressure in the system becomes essentially a vacuum compared to the refrigerant system. Next in line 12 is a recovery solenoid 20 which automatically opens up when the recovery system is started. Low pressure gauge 22 tells the operator how much pressure is in the recovery system as it operates.

Line 12 is then connected to an oil separator unit 24 for separating out the oil from the refrigerant. The conventional oil separator has a filter core trapping the oil which then drops to the bottom of the separator. A heat strap 26 is applied to the bottom of separator 24 to heat the oil. A hand tap 28 allows an operator to periodically drain oil separator 24 into an oil bottle 30.

Filter units 32 and 34 are arranged in tandem to process the refrigerant and remove most of the moisture therefrom. Preferably both filter cores are of a medium pressure, high absorbent type having sufficient filtering capacity to remove most of the moisture in a single pass through two filters. The filter cores are contained in a quick-change assembly comprising a threaded bowl and cap configuration. Preferably, the filter core and assembly are made by Parker Hannafin, Model No. 40-2. The filters preferably include visual

indicators such as lights 36 and 38 which turn on when pressure builds up past a certain level indicating that the filters need to be changed, preferably at 25 psi (17575 Kg/m^2).

A compressor 40 of a conventional type is connected to the filters and functions as a pump to draw refrigerant from the automobile refrigeration system. Downstream from compressor 40 is another conventional oil separator 42 which is used to separate out oil added to the refrigerant by compressor 40. A return line 44 returns the separated oil to compressor 40 to be reused.

The vapor refrigerant is then condensed for storage. Condensing begins by a cooling coil 46, preferably a copper tube coil, ¼" diameter (6.35 mm) and about 4 feet (122 cms) in length. The refrigerant is condensed by a conventional condenser 48, which lowers the temperature to liquify the refrigerant. The liquid refrigerant then passes through another one-way check valve 49 to a collection tank 50 where the non-condensible gas is separated from the liquid refrigerant. A manual shut-off valve 52 connects the output line of collection tank 50 to a conventional storage tank 54. The exhaust line 58 of collection tank 50 is connected to a high pressure switch 60 and to an auto-purge solenoid 62 which in turn is connected to a positive pressure line 64 running back into oil separator 24.

Looking now at FIG. 2, the collection tank 50 is shown in greater detail. Tank 50 preferably includes a top cap 70 and bottom cap 72 sealed to a tubular housing 74. Input refrigerant line 12 is connected to an input port 76 by a connector nut 78. A similar output line 13 is connected to an output port 80 by a port connector 82. An exhaust feed line 64 is connected to the center of the housing cap 70 at port 84 by connector 86. A pick-up tube 88 extends vertically from the output port 80 substantially the full length of tank 50 to end near end cap 72. A mounting screw 90 is provided at the bottom of end cap 72.

Looking now at FIGS. 3 and 4, the control panel 100 and the related electrical

circuitry 120 for the recovery and purification system of the present invention is shown. Typically, the control panel is mounted on the top of a portable cabinet containing all of the apparatus shown in FIG. 1. It is contemplated that this portable unit can be readily moved adjacent to an automobile to be connected directly to its air conditioning system for recovering and purifying the refrigerant therein.

On the lefthand side of control panel 100 is low pressure gauge 22 indicating the pressure of the refrigeration system being evacuated. A hook-up port 101 is provided to connect to the low pressure line of the refrigeration system to be evacuated. An on/off rocker switch 102 turns on power to the recovery and purification system. The cycle start switch 104 turns on the compressor to start up the system. A system operating light 106 confirms that the system is turned on. Filter lights 36 and 38 are provided to indicate when the filter pressure of filters 32 and 34 respectively have exceeded a threshold pressure level requiring the filters to be changed. A high pressure light 110 indicates whether the system has exceeded an acceptable pressure level requiring shutdown. A tank light 112 is shown which is activated by a tank switch 111 and relay 113 when the storage tank in which the liquid refrigerant is being stored is filled to a certain level. A positive pressure switch 108 is also provided to activate the auto-purge solenoid 62 and to direct pressure from collection tank 50 through positive-pressure line 64 to the oil separator unit 24.

In operation, the recovery and purification system of the present invention is connected to a refrigeration system such as the air conditioning system of an automobile. Connection is made from the high and low pressure ports of the automobile air conditioning system to intake port 101. Then rocker switch 102 on instrument panel 100 is pushed on and start switch 104 is momentarily depressed for about 2-3 seconds. This activates relay 105 and system operating light 106 will turn on indicating that compressor 40 has been started

and is beginning to pump refrigerant from the vehicle.

The refrigerant will flow out of the vehicle's air conditioning system and through the micron filter 14 to the oil separator 24. This action will remove the majority of the oil and particles from the refrigerant. The refrigerant is then processed by filter/dryers 32 and 34 to remove substantially all of the moisture therefrom. The vaporized refrigerant then passes through compressor 40 to the compressor oil separator 42 where the compressor oil which has been picked up by the refrigerant is returned to compressor 40. The refrigerant moves on through coil 46 to the condenser 48 preferably having fan circuits 95, 96 and 97, where it is liquified and goes to tank 50 in which the non-condensible gases are separated. The liquified gas is then collected into tank 54 and the non-condensible gases are purged through solenoid 62 and line 64 back into the system at oil separator 24. A high pressure switch 60 is provided to actuate a relay 61 to release an undesirable high pressure buildup in tank 50.

The recovery unit 10 of the present invention will run until substantially all of the refrigerant has been recovered. When the refrigeration system pressure shows 17 inches Hg (431.8 mm) on low pressure gauge 22, vacuum switch 18 will shut off compressor 40, the system operating light 106 will go out and the unit will shut off completely. The positive pressure switch 108 on panel 100 is then depressed for about 3 seconds which activates purge solenoid 62 to provide positive pressure to oil separator 24. Hand tap 28 at the back of the machine is slowly opened to remove oil from the oil separator 26. Preferably the oil is removed into a measuring bottle 30 to be measured so that the proper oil charge may be reinstalled in the new vehicle refrigerant.

Typically, storage tank 54 holds about 28 pounds (12.7 Kgs) and each vehicle air conditioning system comprises about 3.5 to 4 pounds (1.6 to 1.8 Kgs) of refrigerant. After processing about 6 automotive air conditioning systems, tank 54 will register about 80% full.

At that time the liquid level float in the tank will activate the tank switch 111 and relay 113 to automatically shut off the recovery system 10. Tank light 112 comes on showing that the tank is full.

During operation, filters 32 and 34 may become contaminated to the point where they need to be changed. This is normally indicated by pressure in the filter reaching a intolerable level, typically about 25 psi (17575 Kg/in^2). At that point, either or both of filter switches 91, 93 will open and lights 36, 38 on the control panel 100 will turn on indicating that the filter which needs to be changed. At the same time, it is advisable to change the filter core of particulate filter 14.

In changing the filters, the inlet port is capped and rocker switch 102 and cycle start switch 104 are turned on. The unit is allowed to run until the system operating light 106 turns off, indicating that all refrigerant has been pumped out of the filter container. The valve core on the filter to be replaced is depressed, venting the vacuum in the filter canister. The canister is then unscrewed and the old core is replaced. A similar process is used for the particulate filter. Thus, all filters in the system can be easily and quickly removed by using the quick change-out containers so that the system can continue to service additional automotive air conditioning systems.

CLAIMS

1. A one-pass system for recovering and purifying refrigerant from a refrigeration unit and purifying the refrigerant in a single pass through the system, comprising:

(a) filter means for removing particulate materials connected to the refrigeration unit for removing contaminants from the refrigerant;

(b) an oil separator connected to the particulate filter means for removing oil from the refrigerant;

(c) dryer/filter means connected to the oil separator means for removing substantially all of the moisture from the refrigerant in a single pass;

(d) a refrigerant compressor connected to the filter means;

(e) a condenser connected to the refrigerant compressor for liquifying the refrigerant; and

(f) storage means connected to the collector means for storing the liquified refrigerant.

2. A system as claimed in Claim 1 in which the said dryer means comprises multiple dryer units connected in series.

3. A system as claimed in Claim 2 in which the said multiple dryer units each comprise an high moisture absorption filter within a multiple-piece quick-change container.

4. A system as claimed in Claim 2 or Claim 3 in which each filter includes an indicator for sensing and displaying an indication that the filters need to be changed.

5. A system as claimed in Claim 4 in which said indicators each comprise a light which turns on when the pressure in the filter exceeds a predetermined level.

6. A system as claimed in any one of Claims 1 to 5 further including collection means connected to the condenser for separating and removing non-condensible gas from the

liquified refrigerant.

7. A system as claimed in Claim 6 in which the said collection means includes a tank having means therein for separating the liquid refrigerant from the non-condensible gases.

8. A system as claimed in Claim 6 in which the said collection means comprises a tank having a tube running substantially the depth of the tank for collecting the liquid refrigerant from near the bottom of the tank, and purge means near the top of the tank for removing the non-condensible gases.

9. A system as claimed in Claim 8 in which the said purge means includes a positive pressure line running from the top of said tank to said oil separator.

10. A system as claimed in any one of Claims 1 to 9 further including a compressor oil separator connected to the compressor for removing oil added to the refrigerant by the compressor and an oil return line from the compressor oil separator to the compressor for inputing the separated oil back to the compressor.

11. A refrigerant recovery and purification system comprising:

(a) compression means for removing refrigerant from a refrigeration system;

(b) oil separation means for removing oil from the refrigerant;

(c) filter means for removing moisture from the refrigerant;

(d) condenser means for liquifying the refrigerant;

(e) collection means for removing non-condensible gases from the liquified refrigerant; and

(f) storage means for storing the liquified refrigerant.

12. A system as claimed in Claim 11 in which the collection means comprises a tank having liquid collection means therein for removing the liquid refrigerant, and gas collection means therein for removing the non-condensible gases from the refrigerant.

13. A system as claimed in Claim 12 in which the said liquid collection means comprises a tube extending substantially the entire length of the tank for collecting the liquid refrigerant near the bottom of the collection tank.

14. A system as claimed in Claim 12 or Claim 13 in which the said gas collection means comprises an exhaust port in the top of the collection tank and a purge valve connected to the exhaust port for purging non-condensible gases.

15. A system as claimed in Claim 14 in which the said purge valve is connected to the said oil separator to direct the non-condensible gases thereto.

16. A system as claimed in any one of Claims 11 to 15 in which the said filter means comprises multiple filtering units connected in tandem.

17. A system as claimed in Claim 16 in which the said multiple filter units each comprise a high moisture absorption filter within a quick-change canister.

18. A system as claimed in Claim 16 or Claim 17 further including indicator means on

each of said filters for indicating the pressure when the pressure exceeds a predetermined level.

19. A system as claimed in any one of Claims 11 to 18 in which the said compression means further includes compression oil separator means for separating and returning to the compressor the oil added to the refrigerant by the compressor.

20. A system as claimed in any one of Claims 11 to 19 further including switch means for connecting and disconnecting the refrigeration system to said recovery and purification system.

21. A system as claimed in Claim 1 or Claim 11 substantially as specifically described herein with reference to the accompanying drawings.

22. A method of recovering and purifying refrigerant in a refrigeration unit comprising:

(a) pumping the refrigerant from the refrigeration unit into a refrigeration recovery and purification system substantially in vapor form;

(b) removing particulate matter from the vaporized refrigerant;

(c) separating oil from the vaporized refrigerant;

(d) removing all or substantially all of the moisture from the vaporized refrigerant;

(e) condensing all or substantially all of the vaporized refrigerant;

(f) removing the non-condensible gas from the liquified refrigerant; and

(g) storing the liquified refrigerant.

23. A method as claimed in Claim 22 in which the step of removing the non-condensible gases from the liquified refrigerant includes drawing out the liquified refrigerant and purging the non-condensible gases.

24. A method as claimed in Claim 23 in which the said purging step includes applying the non-condensible gases to the recovery and purification system to equalize the pressure

in the refrigerant recovery and purification system.

25. A method as claimed in Claim 22, 23 or 24 in which the said filtering step comprises pumping the vaporized refrigerant through multiple filters in tandem to remove substantially all of the moisture from the vaporized refrigerant.

26. A method as claimed in Claim 25 in which the said pumping step includes drawing the vaporized refrigerant from the refrigeration system by use of a compressor.

27. A method as claimed in Claim 26 further comprising the step of removing oil from the vaporized refrigerant after it has gone through the compressor and returning the oil to the compressor for use by the compressor.

28. A method of removing refrigerant from a refrigeration unit into a refrigeration recovery and purification system and purifying the refrigerant in a single pass through said system comprising:

(a) pumping the refrigerant from the refrigeration unit into the system with a compressor;

(b) removing the particulate matter from the vaporized refrigerant;

(c) separating the oil from the vaporized refrigerant;

(d) pumping the vaporized refrigerant through multiple filter units to remove substantially all of the moisture therefrom in a single pass;

(e) liquifying all or substantially all of the vaporized refrigerant using a condenser; and

(f) storing the liquified refrigerant.

29. A method as claimed in Claim 28 further including removing the liquified refrigerant from residual non-condensible gases before storing the liquified refrigerant.

30. A method as claimed in Claim 29 and further including purging the non-condensible

gases from the system.

31. A method as claimed in Claim 30 in which the said purging step includes directing the non-condensible gases to the oil separator to assist in the removal of the oil from the oil separator.

32. A collection unit for use in a refrigerant recovery system for separating liquified refrigerant from non-condensible gases, comprising: a receptacle for receiving the liquified refrigerant and non-condensible gases; input means for connecting the receptacle to a refrigerant line containing a liquified refrigerant with non-condensible gases therein; output means for connecting the receptacle to an output line for the liquified refrigerant; collection means connected to the output means for collecting only liquified refrigerant from within the receptacle; and exhaust means connected to the receptacle and communicating with the non-condensible gases in the receptacle for venting the gases from the receptacle.

33. A collection unit as claimed in Claim 32 in which the receptacle is an elongated sealed tank with the input port, output port and exhaust port mounted thereon.

34. A collection unit as claimed in Claim 33 in which the input means is connected to the input port, the output means is connected to the output port and the exhaust means is connected to the exhaust port.

35. A collection unit as claimed in Claim 33 or Claim 34 in which the collection means is a tube running from the output port substantially the entire length of the tubular tank.

36. A collection unit as claimed in any one of Claims 33, 34 or 35 in which the exhaust means is a vent connected to the exhaust port of the tank.

37. A collection unit as claimed in Claim 32 substantially as specifically described herein with reference to the accompanying drawings.

38. A method as claimed in Claim 22 or Claim 28 substantially as specifically described herein with reference to the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

920945.3

Relevant Technical fields

(i) UK Cl (Edition K) F4H

(ii) Int Cl (Edition 5) F25B

Search Examiner

M C MONK

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search

24.3.92

Documents considered relevant following a search in respect of claims 1-31

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	US 4805416 A (KENT-MOORE) whole document	11, 22 at least
X	US 4768347 A (KENT-MOORE) whole document	"
X	US 4441330 A (ROBINAIR) whole document	"

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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